Bias correction and probabilistic skill in seasonal forecasts based on NMME

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In this talk

- Datasets used
- Time-dependent bias: observed vs. NMME trends
- Ensemble dispersion vs. forecast error
- Impact of mean & variance bias on skill metrics
- Directions for improvement

Datasets and methods

- **NMME monthly hindcasts/forecasts initialized 1982-2013 (384 forecast times)**

  Only models that continue to run till present (CMC1-CanCM3, CMC2-CanCM4, GFDL-CM2p1-aer04, COLA-RSMAS-CCSM3)

  Only 2-m temperature (tref)

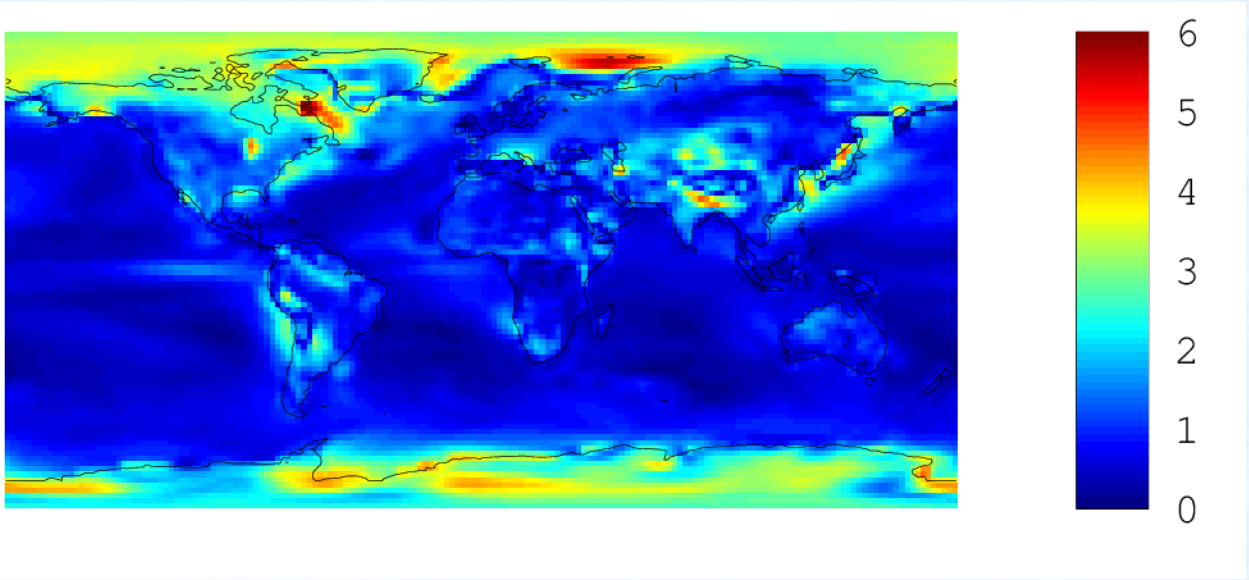
  Only seasonal average, 1.5-3.5 month lead

  Regridded to 2° resolution to match validation data

- **Validation: GISS land-ocean temperature index**
- **Probabilistic forecasts constructed using normal PDF, with mean from either climatology or NMME, and SD from either climatology or NMME spread**
- **Negative log likelihood was primary skill metric (see Krakauer et al. (2013), "Information content of seasonal forecasts in a changing climate", AMET for details)**

Need for bias correction is very clear

Inter-model SD of the mean state, DJF (K)



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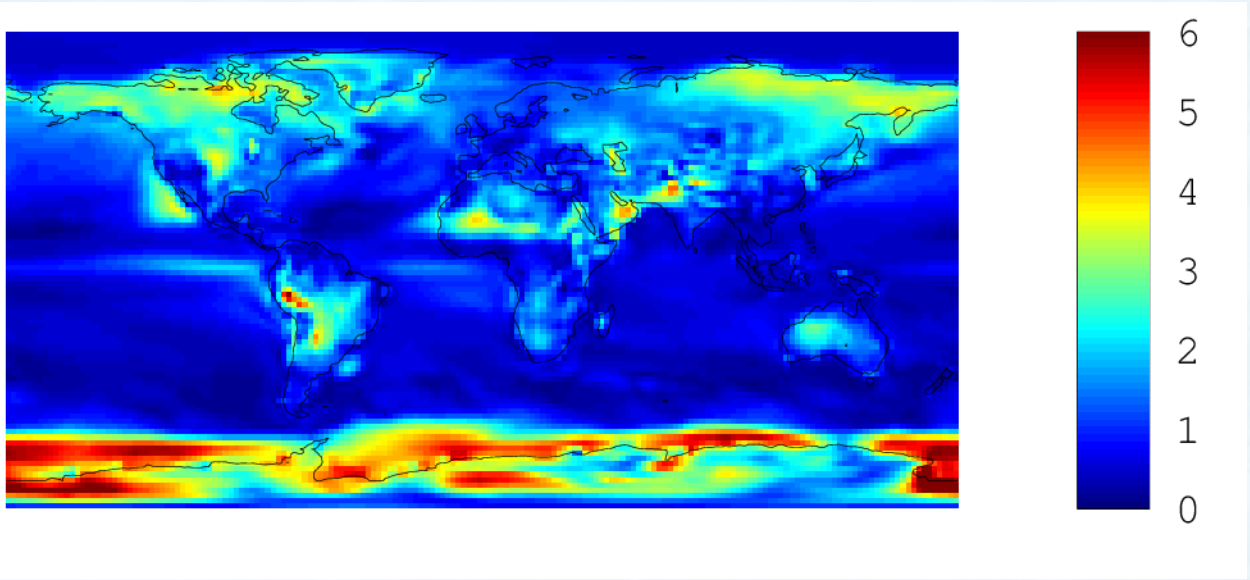
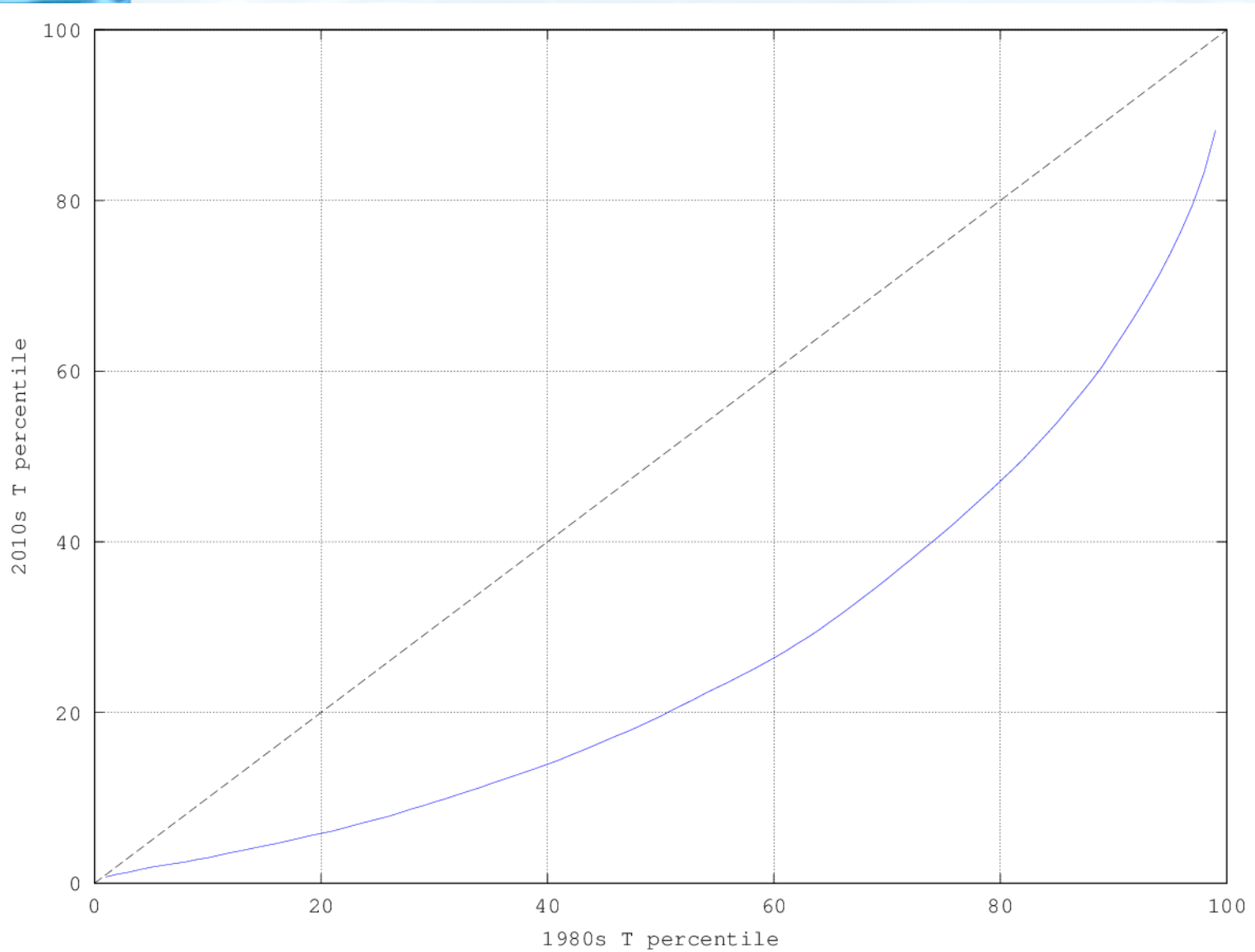


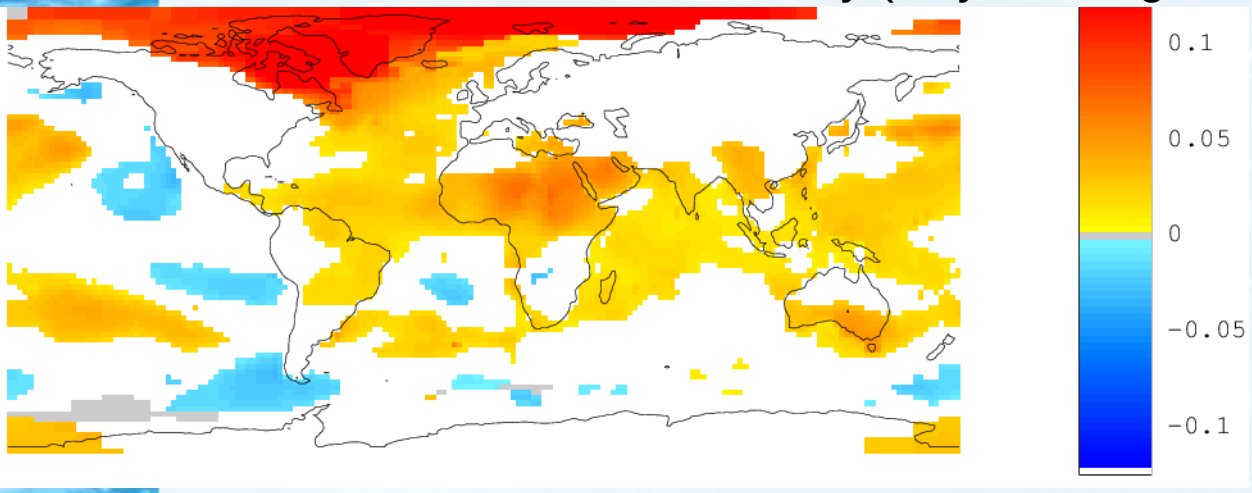
More subtly, global warming is reshaping temperature PDFs



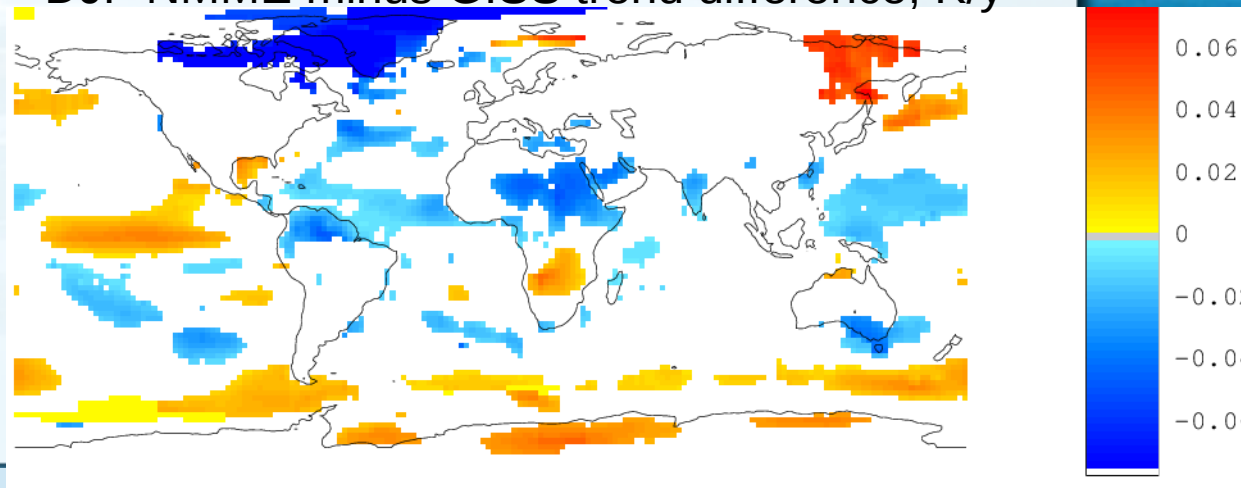
- A 1980s median season would be at the 20th percentile now
- Today's median is above the 1980s 80th percentile
- Misrepresented trends in NMME could introduce time-varying bias

NMME vs. GISS trends

DJF GISS trend 1982-2013, K/y (only 95% significant trends shown)



DJF NMME minus GISS trend difference, K/y



- NMME on average underestimates the observed warming, with geographic variation

NMME vs. GISS trends

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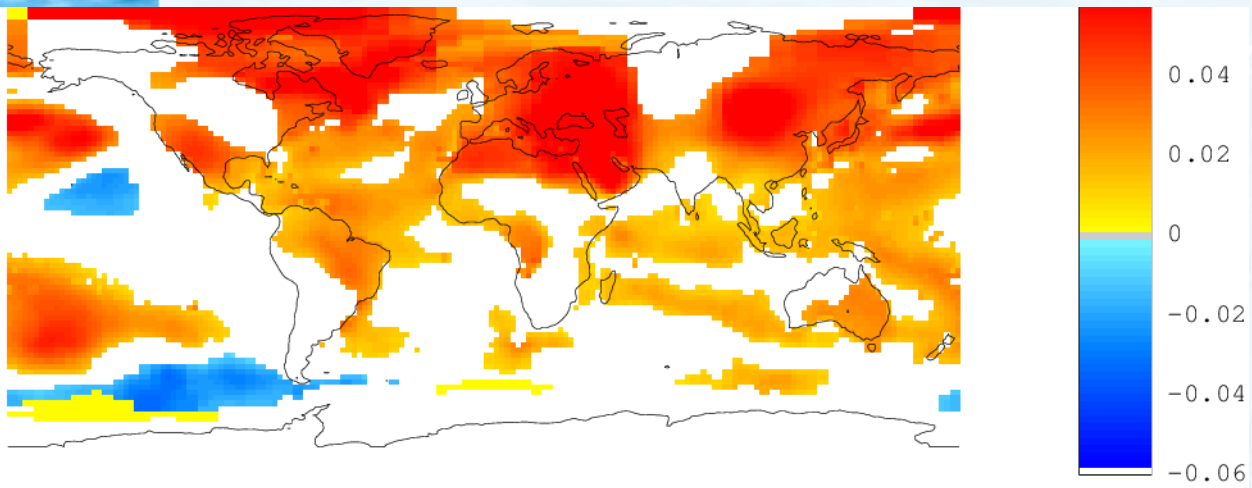

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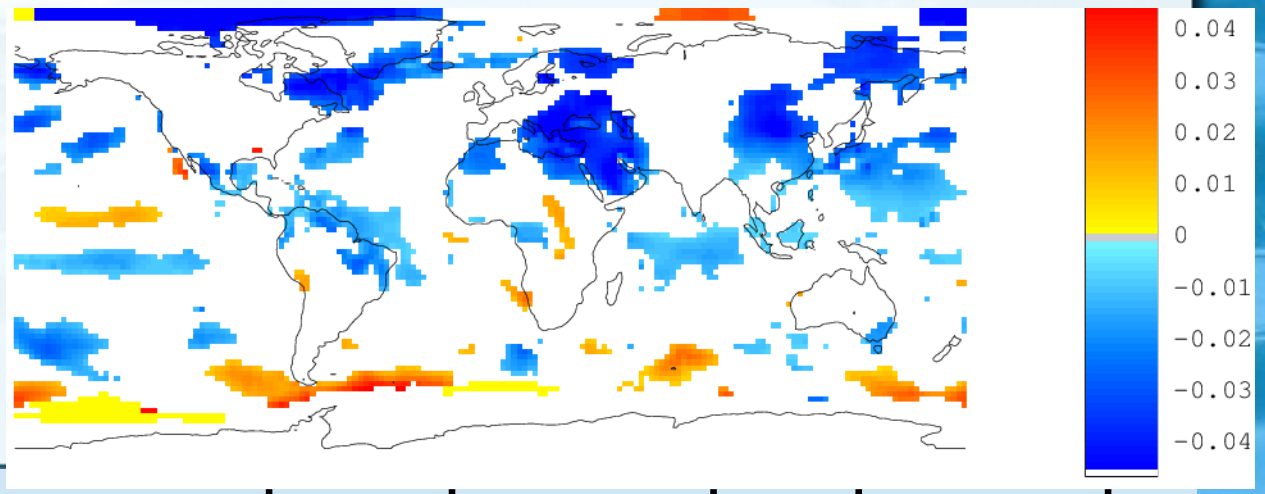

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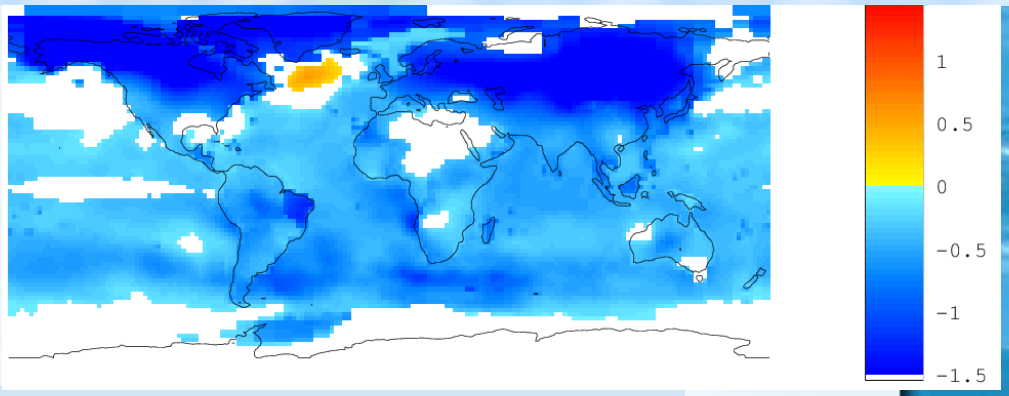
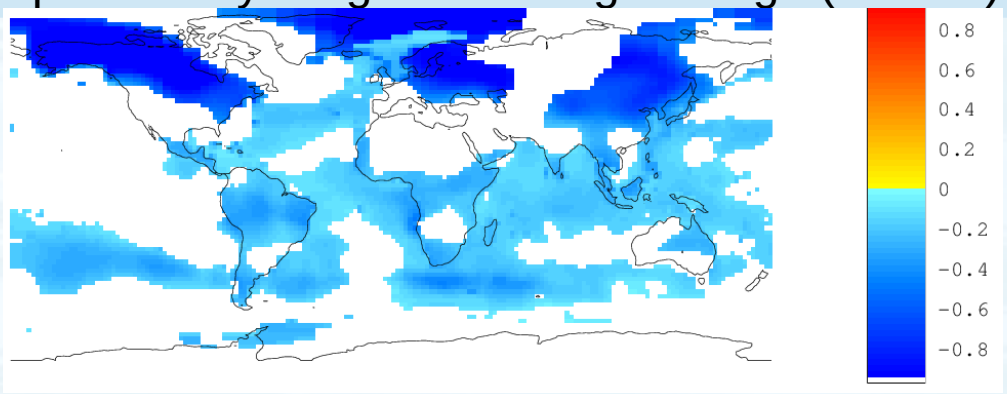
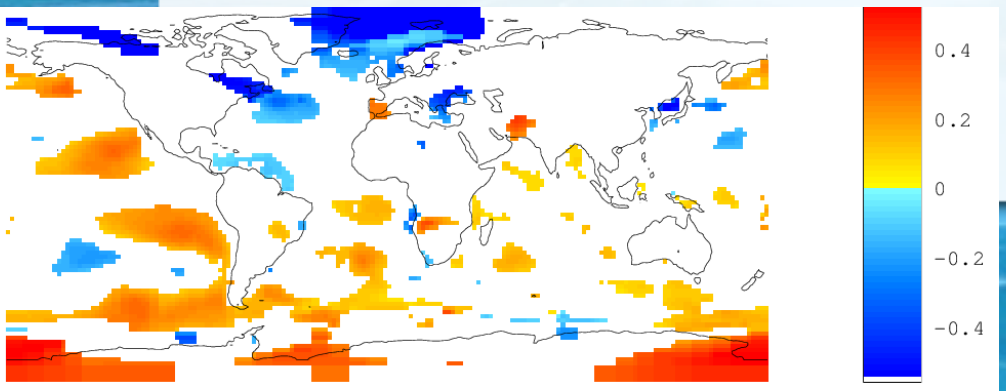
A reduced-bias updated climatology

Bias of DJF climatology forecast (K)



Bias of DJF 15-year exponentially weighed moving average (EWMA) forecast (K)

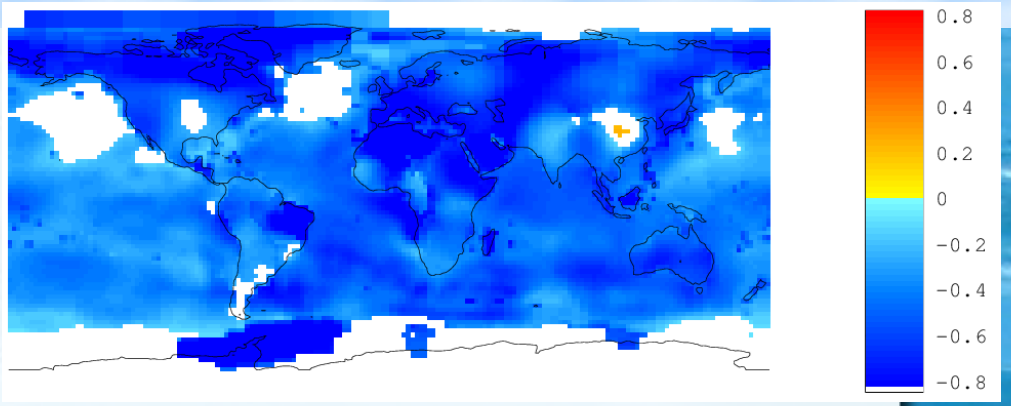




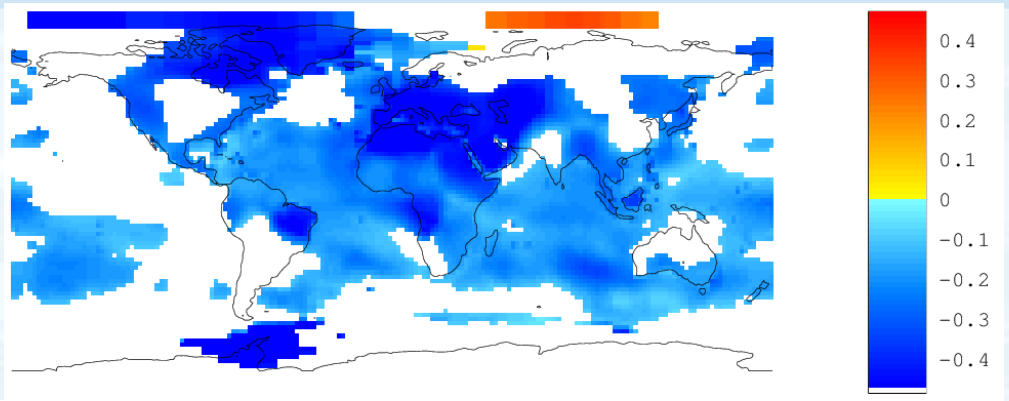
Bias of DJF linear regression forecast, $b_1 + b_2$*EWMA (K)

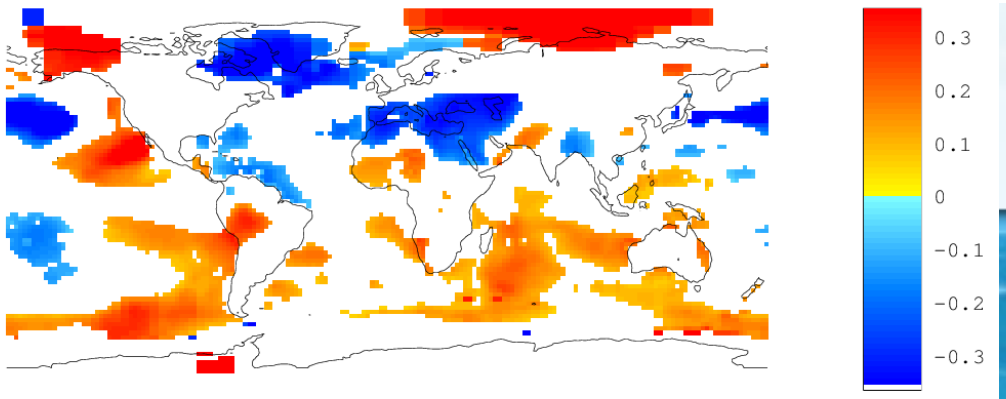
A reduced-bias updated climatology

Bias of JJA climatology forecast (K)



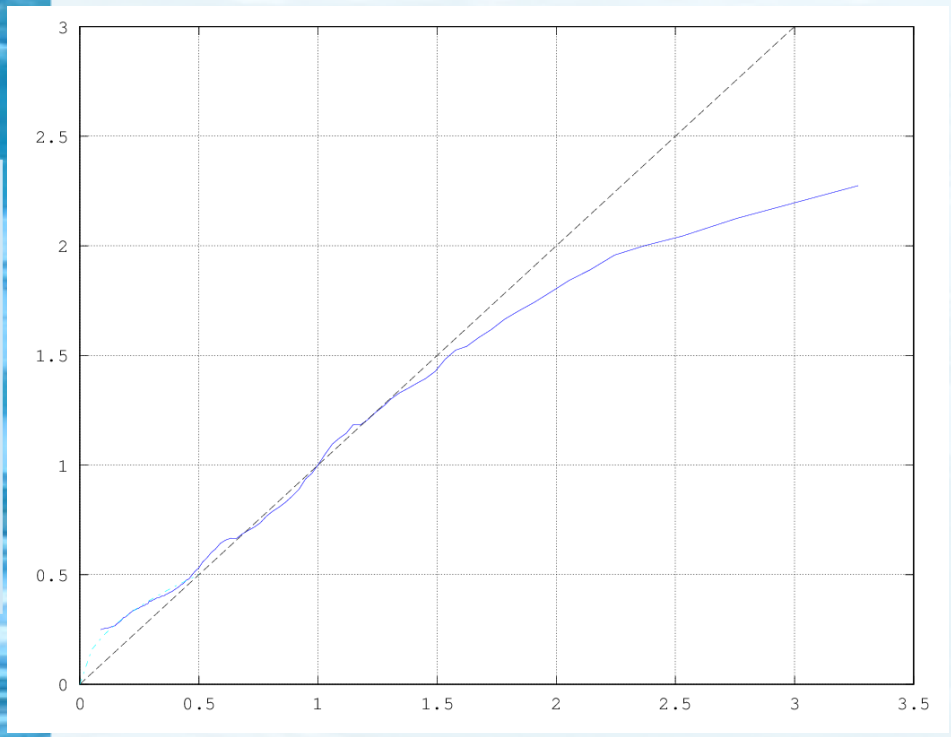
Bias of JJA 15-year exponentially weighed moving average (EWMA) forecast (K)





Bias of JJA linear regression forecast, $b_1 + b_2$*EWMA (K)

Ensemble dispersion



- After seasonally-specific mean bias correction, the ensemble standard deviation correlates rather well with forecast error
- However, the ensemble is overconfident when its SD is below median (<0.5 K)
- Overall, using climatology SD gives better probabilistic forecasts than using ensemble SD

Effect of bias on skill scores

- Mean hindcast/forecast negative log likelihood, relative to a reference (bits):

worse forecast

better forecast

–	Climatology	+0.66
–	NMME or EWMA	+0.07
–	NMME regression	+0.02
–	EWMA regression (reference)	0
–	NMME + EWMA regression	-0.08
–	NMME models + EWMA regression	-0.09

Note: 50% reduction in forecast error = 1 bit

Model failure to reproduce trends (time-varying bias) worsens seasonal forecasts to an extent that offsets any skill in simulating the dynamics of sources of persistence

Effect of dispersion on skill scores

- Mean hindcast/forecast negative log likelihood, relative to a reference (bits):

worse forecast

better forecast

– NMME: NMME SD	+0.24
– NMME: max(NMME SD, 0.5 K)	+0.15
– NMME: EWMA SD	+0.07
– EWMA regression (reference)	0

Skill is sensitive to the forecast standard deviation used, as well as the mean

Needs

Short term

Statistical methods to remove bias from seasonal forecasts using currently available outputs

Medium term

Long reforecast series for all seasonal forecast systems to enable improved bias assessment (GISS temperature fields for verification, e.g., are available since 1880)

Long term

Get warming trends right in models used for seasonal forecasts (realistic radiative physics, up-to-date initializations of temperature (including deep ocean), sea ice, land cover, snow and glaciers...)

Questions?

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